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13.4 Socio-economic Impacts and Extension Process of Conservation Biological Control in Mango Orchards in Réunion Island

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In Réunion Island, mango trees are confronted with a variety of pests (Miridae, Tephritidae, Cecidomyiidae, Thripidae, Coccidae, Acari) and diseases (bacteriosis, anthracnose, oidium) (Amouroux and Normand, 2013). This has led, over the years, to the increasing use of pesticides, in particular insecticides and herbicides. This agrochemical protection has its limitations: reduced insecticide efficacy on pests, weed resistance to herbicides, negative effects on the environment (soil, water) and on biodiversity (animals and plants) on an island internationally recognised as a biodiversity hotspot (Myers, 2003). There are also health risks for producers and consumers and ecological imbalances.

To replace this conventional agrochemical protection, an agroecological crop protection experience, based on conservation biological control (Deguine *et al.*, 2017), was initiated in Réunion Island in mango orchards in 2010. After two years of co-design with a large number of agricultural stakeholders, a Research and Development project, Biophyto, tested agroecological crop protection principles between 2012 and 2014 in a network of 12 pilot orchards. After this experimental phase, the dissemination of conservation biological control practices to other mango producers was carried out via transfer agencies and the government. Our study aims at presenting the main socio-economic results of the agroecological management of mango orchards in Réunion Island based on conservation biological control.

The Biophyto project: a conservation biological control experiment in conjunction with growers: The Biophyto project brought together a network of farmers and agricultural actors (research, experimentation, advisory, training, education, transfer, public authorities) with the aim of implementing agroecological practices using the principles of conservation biological control (Ferron and Deguine, 2005). These practices have enabled insecticide and herbicide treatments to be eliminated via the establishment of permanent plant cover in orchards to promote functional biodiversity below the mango canopy. In this project, it was possible to compare the performance of conventional (agrochemical) and agroecological orchards. The results of this experiment are very encouraging and may be useful to

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understand the ecological functioning of other tropical crops (http://www.agriculture-biodiversite-oi.org/Biophyto).

The farmers involved in the Biophyto project all adopted agroecological practices to a certain degree. Overall, these practices have proven to be effective in the promotion of plant health, in preserving the environment, adapted to the context, and easy to implement.

The role of biodiversity in the ecological functioning of mango orchards has been thoroughly studied and original knowledge about it has been acquired (Jacquot, 2017). As an illustration, over 120,000 arthropods were collected in orchards including nearly 800 morpho-species. Amongst these species, only a few can be considered as mango pests, while nearly 200 belong to the parasitoid guild.

During the Biophyto project, growers were informed and trained about the important role of functional biodiversity and the effectiveness of conservation biological control. With the use of agroecological practices (permanent vegetation cover, stopping insecticide and herbicide treatments), growers became aware of the existence and the important role of many other trophic groups (weeds, detritus, herbivores, detritivores, predators, parasitoids, pollinators, hyperparasitoids, etc.). They realised that the vast majority of arthropods present in their orchards were not harmful to mango trees, and that they were important for the stability of ecological balances.

During the three years of the project, insecticide and herbicide treatments were greatly reduced, and in most cases completely eliminated. At the same time, production costs were reduced by 35%. Overall, there were no production losses between agrochemical and agroecological plots except in rare instances where gall midge attacks were observed on a vulnerable mango variety. The added economic value was particularly appreciated by growers and was one of the reasons why the practices proposed were quickly applied in all orchards of the project during and after the Biophyto project.

After Biophyto: the transfer of practices by agencies and authorities: After the Biophyto project, the organizations for agricultural transfer (Association of Producers, Chamber of Agriculture) became involved and were accompanied by the authorities so that conservation biological control practices could be promoted and disseminated. Several development tools were created and implemented. First, a reference network of demonstration plots named "DEPHY FERME MANGUE" was set up in Réunion Island. Numerous visits were organized for mango growers so that they could experience a first approach of the agroecological practices. Secondly, an agricultural and environmental measure was set up to encourage producers to commit themselves to the agroecological protection of orchards. They benefitted from a grant of 900€/ha per year over a period of 5 years, providing that a permanent vegetation cover was maintained on the entire orchard (including flower strips on at least 5% of the farm). Thirdly, since conservation biological control is much more effective when it is used at a large scale like a production basin, an Economic and Environmental Interest Group was created at the request of mango growers from the main production area in Réunion Island, with the aim of establishing collective actions (including the management of agroecological practices).

Moreover, in Réunion Island, there is a general interest in the consumption of organic products. Since the Biophyto project, many mango producers have converted to organic farming. This move has been financially supported by the public authorities.

Finally, this agroecological experiment gave rise to a university-accredited diploma designed and implemented for growers and agricultural professionals. A professional qualification University certificate (CUQP), entitled "Agroecological Crop Protection" and

awarded by the University of Réunion was designed with partners. Professionals who have graduated then act as leaders in the field and contribute effectively to the transfer and dissemination of conservation biological control practices.

Conclusion: After successful trials in Réunion Island on vegetable crops (more than half of the chayote production is organic in 2017 compared to 0% in 2009), agroecological protection based on conservation biological control was applied to mango orchards. This experience shows that an agroecological approach can be adopted in a producer environment while maintaining or even improving socio-economic performance. Beyond these socio-economic aspects, the positive impacts of conservation biological control on the environment and on human health became clear. Different professionals, including growers, are also becoming aware that conservation biological control practices contribute significantly to the ecological sustainability of agroecosystems. Other experiments are in process in Réunion and in the neighbouring countries of the Indian Ocean.

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